A BIOLOGICAL ASSESSMENT OF SITES IN THE TWO MEDICINE RIVER WATERSHED: PONDERA, GLACIER and TETON COUNTIES, MONTANA

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A report to

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by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in August and September 2002 from 14 sites in the Two Medicine River Watershed, Pondera, Glacier and Teton Counties, Montana. Eleven of the sites in this study lie within the Montana Valley and Foothill Prairies (MVFP) ecoregion (Woods et al. 1999) the other three sites lie within the Northwest Glaciated Plains ecoregion.

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

METHODS

Samples were collected in August and September 2002 by Montana DEQ personnel. Sample designations and site locations are indicated in Table 1a. The site selection and sampling method employed were those recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). The Kick collection procedure was employed for all samples; duration and length are indicated in Table 1b. Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

Table 1a. Sample designations and locations. Sites are listed by drainage in upstream-to-downstream order. Two Medicine River Watershed, August and September 2002.

Site	Station ID	Activity ID	Location Description	Latitude/ Longitude
Dupuyer Creek Drainage				
DC1	M15DUPNF01	02-L419-M	Dupuyer Creek- North Fork	48°05'39"/112°43'00"
DC2	M15DUPSF01	02-L420-M	Dupuyer Creek- South Fork	48°05'13"/112°41'36"
DC3	M15DUPYC02	02-L418-M	Dupuyer Creek at Anderson	48°10'51"/112°32'36"
DC4	M15DUPYC03	02-L426-M	Dupuyer Creek at Pondera Colony	48°12'09"/112°28'37"
DC5	M15DUPYC04	02-L427-M	Dupuyer Creek downstream of Hwy 44 Bridge near mouth	48°17'50"/112°20'25"
Birch Creek Drainage				
BC1	M15SFBHC01	02-LC205-M	Birch Creek South Fork upstream 5 mi.	48°23.064'/112°53.85'
BC2	M15BRCHC01	02-L425-M	Birch Creek upstream of County Bridge	48°13'54"/112°44'44"
BC3	M15BRCHC02	02-L430-M	Birch Creek at Deboo's Ranch	48°16'28"/112°36'21"
BC4	M15BRCHC03	02-L429-M	Birch Creek downstream of County Road crossing	48°20'46"/112°29'16"
BC5	M15BRCHC05	02-L428-M	Birch Creek near mouth	48°23'29"/112°18'44"
South Fork Two Medicine River Drainage				
TM1	M15SFTMR02	02-LC203-M	Two Medicine River – South Fork ½ mi d/s of Townsend Creek	48°18.744'/113°17.256'
TM2	M15SFTMR01	02-LC204-M	Two Medicine River – South Fork downstream	48°21.69'/113°14.976'
Mainstem Two Medicine River Drainage				
TM3	M15TMEDR01	02-L414-M	Two Medicine River near mouth	48°29'01"/112°13'37"
Railroad Creek Drainage				
RC1	M15RLRDC01	02-LC250-M	Railroad Creek west of Reservation	48°24'29.7"/113°14'16.4"

Table 1b. Sample collection procedure, duration, and length. Two Medicine River Watershed, August and September 2002.

Site	Date	Collection Procedure	Duration	Length
DC1	9-13-02	KICK	2 MINUTES	30 FEET
DC2	9-13-02	KICK	2 MINUTES	30 FEET
DC3	7-11-02	KICK	1 MINUTE	20 FEET
DC4	9-11-02	KICK	2 MINUTES	30 FEET
DC5	9-12-02	KICK	1 MINUTE	20 FEET
BC1	8-27-02	KICK	Not Recorded	Not recorded
BC2	9-11-02	KICK	2:20 MINUTES	40 FEET
BC3	9-12-02	KICK	2:30 MINUTES	35 FEET
BC4	9-12-02	KICK	1:30 MINUTES	35 FEET
BC5	9-12-02	KICK	1 MINUTE	20 FEET
TM1	8-24-02	KICK	Not Recorded	Not Recorded
TM2	8-25-02	KICK	Not Recorded	Not Recorded
TM3	8-29-02	KICK	2 MINUTES	40 FEET
RC1	9-18-02	KICK	Not Recorded	Not Recorded

Assessment of Montana Valley and Foothill Prairies (MVFP) sites

To assess aquatic invertebrate communities from MVFP sites in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used for MVFP sites in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in the Blackleaf Creek watershed. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.

2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.

3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).

5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of the Montana Valley and Foothill Prairies ecoregion (Bollman 1998a).

	Score			
Metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

Table3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric

battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

Assessment of Northwestern Glaciated Plains sites

Bioassessment metric selection for the three sites located in the Northwestern Glaciated Plains ecoregion was based on the recommendations found in the Montana DEQ standard operating procedures (Bukantis 1998). The metric battery and scoring criteria are illustrated in Table 4.

Table 4. Provisional metrics and scoring criteria for the Montana Plains ecoregions. (Bukantis, 1998).

	Score			
Metric	**3**	**2**	**1**	**0**
Taxa richness	>24	24 - 18	18 – 12	<12
EPT richness	>8	8 – 6	5 – 3	<3
Biotic Index	<5	5 – 6	6 – 7	>7
% Dominant taxon	<30	30 – 45	45 – 60	>60
% Collectors	<60	60 – 80	80 – 95	>95
% EPT	>50	50 – 30	30 – 10	<10
Shannon H (log2)	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% Scrapers + shredders	>30	30 – 15	15 – 3	<3
# Predator taxa	>5	4 – 5	3 – 4	<3
% Multivoltine	<40	40 - 60	60 – 80	>80

These metrics should be considered provisional, since correlative relationships between them and meaningful measures of habitat condition and water quality have not been evaluated. Assurance of the validity of associations between meaningful habitat measures and biotic metrics is particularly compelling in the Plains ecoregion, since impairment of the biotic health of streams in this region is generally the result of non-point sources of water quality degradation and habitat disturbance. Agricultural activities, including cattle grazing and flow alteration, are predominant causes of disturbance. The benthic assemblages of the Plains ecoregions, and the performance of bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Thus, conclusions concerning bioassessment based upon these metrics must be regarded as tentative.

RESULTS

Habitat Assessment

Figure 1 graphically compares total habitat assessment scores recorded for thirteen sites in this study. Tables 5a, 5b and 5c show the habitat parameters evaluated, parameter scores and overall habitat evaluations for the sites studied in the Dupuyer, Birch and Two Medicine and Railroad Creek Drainages, respectively. No habitat assessment was provided for the site near the mouth of the Two Medicine River (Site TM3). Habitat conditions were generally judged to be good; scores suggest optimal or sub-optimal overall habitat quality at all evaluated sites.

On the North Fork of Dupuyer Creek, instream and riparian zone habitat features at Site DC1 were perceived to be undisturbed. Field personnel noted that moderate streambank instability was natural, given the limited topsoil in the valley and the flashy hydrologic pattern

of the stream. The South Fork site (DC2) was assigned optimal scores for all evaluated parameters.

On the mainstem of Dupuyer Creek, Site DC3 was judged to have excellent instream and riparian zone integrity. Moderate streambank instability was noted on one side of the stream reach, where some slumping was noted. Field notes indicate that vegetation was becoming established and that stability appeared to be improving. Downstream at Site DC4, habitat was perceived to be intact, except for the encroachment of a hayfield that limited the extent of the riparian zone. Instream and streambank parameters were judged to be in good condition. Near the mouth of Dupuyer Creek (Site DC5), instream habitat parameters were perceived to be good, but flow conditions were rated marginal. In addition, streambank vegetation was assigned a low score because of a high proportion of opportunistic and/or noxious species.

Site BC1 on the South Fork of Birch Creek was perceived to have undisturbed instream habitat features, but poor streambank vegetation cover was noted in the reach. In addition, riparian zone width scored marginally on one side of the stream. On the mainstem of Birch Creek, Site BC2 was reported to have apparent channel alteration, but field notes indicate that investigators were unsure of how much alteration was due to natural versus anthropogenic influences. Poor soils were thought to be responsible for moderate streambank instability and lack of vegetative cover; parent materials (glacial gravels and cobbles) formed the primary ground cover. Instream, streambank and riparian zone features were all judged to be relatively undisturbed at Sites BC 3 and BC4. Near the mouth of Birch Creek, habitat features remained in good condition according to evaluators. On one side of the stream at Site BC5, however, the moderate instability of the adjacent terrace resulted in sediment contributions, especially during storm events. Poor vegetative cover and low potential for such cover was judged to be a consequence of thin or nonexistent topsoil.

On the South Fork of the Two Medicine River, instream habitat features were judged to be in good condition at Site TM1. Moderate instability of the streambank on the left side of the channel, disruption of vegetation, and limited riparian zone width were attributed to scour from past flooding. At Site TM2, instream habitat quality was judged to be limited by embedded substrate. Flow conditions were perceived to be marginal. Moderate streambank instability was attributed to natural erosion, and marginal vegetative cover was perceived to be caused by scarring during high flows. Limited riparian zone width was also noted.

On the mainstem of the Two Medicine River, instream habitat parameters scored optimally. Streambank stability and riparian zone width were limited on the left side of the channel by proximity to a naturally erosive sandstone valley wall.

On Railroad Creek, Site RC1 was judged to have essentially undisturbed habitat features except for limited riparian zone width.

Figure 1. Total habitat assessment scores for 13 sites in the Two Medicine River Watershed. August and September 2002.

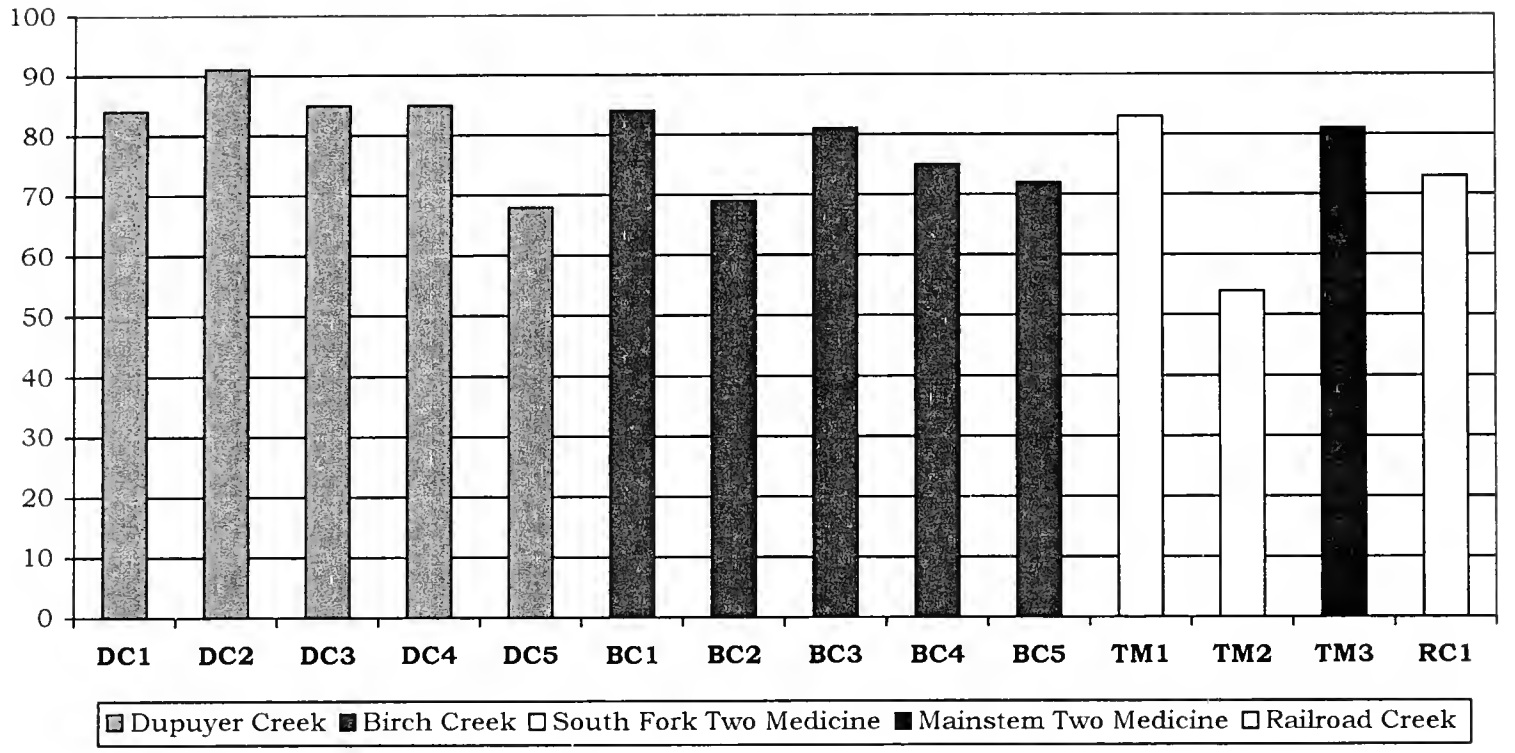


Table 5a. Stream and riparian habitat assessment. The five Dupuyer Creek Drainage sites were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence. September 2002.

Max. possible score	Parameter	Dupuyer Creek Drainage DC1	DC2	DC3	DC4	DC5
10	Riffle development	9	9	8	6	6
10	Benthic substrate	10	10	9	9	9
20	Embeddedness	18	18	18	18	18
20	Channel alteration	18	20	18	18	17
20	Sediment deposition	18	18	18	18	13
20	Channel flow status	18	20	18	18	6
20	Bank stability	5 / 5	9 / 9	5 / 9	10 / 7	8 / 8
20	Bank vegetation	8 / 8	9 / 9	7 / 10	10 / 7	5 / 5
20	Vegetated zone	10 / 7	6 / 8	6 / 10	10 / 5	8 / 6
160	Total	134	145	136	136	109
	Percent of maximum	**84%**	**91%**	**85%**	**85%**	**68%**
	CONDITION*	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**	**SUB-OPTIMAL**

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1989.

Table5b. Stream and riparian habitat assessment. The five Birch Creek Drainage sites were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence. August and September 2002.

Max. possible score	Parameter	Birch Creek Drainage BC1	BC2	BC3	BC4	BC5
10	Riffle development	10	9	9	8	7
10	Benthic substrate	10	9	9	9	9
20	Embeddedness	19	18	18	18	16
20	Channel alteration	20	10	18	11	18
20	Sediment deposition	15	17	17	17	17
20	Channel flow status	19	18	16	14	17
20	Bank stability	10 / 10	5 / 5	7 / 9	7 / 8	9 / 5
20	Bank vegetation	8 / 2	3 / 3	7 / 9	6 / 6	7 / 2
20	Vegetated zone	9 / 3	7 / 7	6 / 6	8 / 8	6 / 3
160	Total	135	111	131	120	116
	Percent of maximum CONDITION*	**84% OPTIMAL**	**69% SUB-OPTIMAL**	**81% OPTIMAL**	**75% SUB-OPTIMAL**	**72% SUB-OPTIMAL**

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1989.

Table 5c. Stream and riparian habitat assessment. The sites in the South Fork Two Medicine River Drainage and single sites in the Mainstem Two Medicine River Drainage and the Railroad Creek Drainage were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence. August and September 2002.

		South Fork Two Medicine River Drainage		**Mainstem Two Medicine River Drainage**	**Railroad Creek Drainage**
Max. possible score	**Parameter**	**TM1**	**TM2**	**TM3**	**RC1**
10	Riffle development	9	9	9	7
10	Benthic substrate	9	7	8	8
20	Embeddedness	18	10	18	15
20	Channel alteration	19	15	17	12
20	Sediment deposition	19	12	17	13
20	Channel flow status	18	10	18	20
20	Bank stability	5 / 9	3 / 3	7 / 9	8 / 8
20	Bank vegetation	5 / 8	4 / 5	6 / 7	6 / 8
20	Vegetated zone	10 / 4	4 / 5	6 / 8	3 / 9
160	Total	133	87	130	117
	Percent of maximum CONDITION*	**83% OPTIMAL**	**54% SUB-OPTIMAL**	**81% OPTIMAL**	**73% SUB-OPTIMAL**

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. (Plafkin et al. 1989)

Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled in the Two Medicine River Watershed. Table 6 itemizes each contributing metric and shows individual metric scores for each site located in the Montana Valley and Foothill Prairie ecoregion and Table 7 itemizes each contributing metric and shows individual metric scores for the sites located in the Northwestern Glaciated Plains ecoregion. Tables 3a and 3b above show criteria for impairment classifications (Plafkin et al. 1989) and use-support categories recommended by Montana DEQ (Bukantis 1998).

Applying these bioassessment methods to the data results in scores suggesting widely varying biologic condition at the sites in this study. In the Dupuyer Creek drainage, the North Fork site (DC1) appeared to be unimpaired and fully supportive of designated uses. The South Fork site (DC2), and all 3 sites on the mainstem of Dupuyer Creek (DC3, DC4, and DC5) received scores implying moderate impairment. The site on the South Fork (DC2) and 2 sites on the mainstem (DC 3 and DC4) partly supported designated uses, but the Dupuyer Creek site near the mouth (DC5) did not support uses.

In the Birch Creek drainage, analysis of the benthic assemblage collected at the South Fork site (BC1) yielded scores indicating unimpaired biologic condition and full support of uses. Upstream of the County Bridge, Site BC2 apparently was slightly impaired and only partly supported uses. Sites BC3 and BC5 were moderately impaired and partly supported designated uses. And site BC4, downstream of the County Road crossing was severely impaired and did not support uses. Samples taken at Sites BC2 and BC3 yielded small numbers of organisms, making bioassessment unreliable.

In the Two Medicine River drainages, the South Fork site downstream of Townsend Creek (Site TM1) yielded a sample with too few organisms for reliable bioassessment. The Two Medicine River site near the mouth (Site TM3) was assessed as non-impaired and fully supportive of designated uses, while Site TM2 on the South Fork appeared to be slightly impaired and only partly supported uses.

Site RC1 on Railroad Creek yielded scores suggesting slight impairment but full use support.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

The Dupuyer Creek drainage

The site on the North Fork of Dupuyer Creek (DC1) supported 8 mayfly taxa and the biotic index value (1.93) calculated for the sampled assemblage was very low. These findings suggest that water quality was excellent at this site. Two sensitive cold-stenotherms were collected, the stonefly *Megarcys* sp. and the mayfly *Drunella doddsi*. These 2 taxa accounted for 27% of sampled organisms. Cold clean water apparently characterized this site.

The 2 indicators of fine sediment deposition gave contradictory results for this assemblage. Seventy-four percent of sampled organisms were "clingers", ten taxa were represented. This suggests that fine sediment deposition did not appreciably limit access to hard stony substrates. Only 2 caddisfly taxa were present in the sample, which could be

interpreted as a signal that sediment deposition was a problem at the site. However, the strong proportional representation of "clingers" is more convincing evidence. Five stonefly taxa were collected, suggesting that reach-scale habitat features such as a functional riparian zone, stable streambanks, and natural channel morphology, were essentially intact. Four long-lived taxa were present; it is likely that dewatering or other limiting catastrophes did not affect this system recently. Functionally, the assemblage appears to be skewed toward gatherers, with less contribution from shredders than expected. This could be due to a lack of riparian inputs of large organic debris, or perhaps flow conditions did not favor the retention of such material.

On the South Fork, Site DC2 yielded 4 mayfly taxa, which is somewhat fewer than expected. Still, the biotic index value (3.55) was not greatly elevated relative to expectations for a foothill stream. However, no sensitive taxa were collected, and the taxa richness was quite high; thirty-three taxa were represented in the sample. Fully a quarter of animals collected were tolerant taxa. The dominant taxon was the filter-feeding blackfly *Simulium* sp., which made up 20% of sampled animals. These findings suggest that very mild nutrient enrichment may have affected the taxonomic composition of the benthic assemblage at this site. The presence of lymnaeid and physid snails adds strength to this hypothesis.

Fifteen "clinger" taxa and 8 caddisfly taxa were collected, suggesting that fine sediment deposition did not significantly impair habitat quality at this site. The number of predator taxa (8) collected in the sample suggests that instream habitats were diverse and abundantly available. There were fewer stonefly taxa (3) than expected, which may indicate some disruption of reach-scale habitat features, such as riparian function or streambank stability. All functional components expected in a healthy benthic assemblage in a foothill stream were present in what appeared to be appropriate proportions. The ample contribution from shredders suggests that large organic inputs were plentiful, and that hydrologic conditions favored retention of such material. No fewer than 10 long-lived taxa were collected, strongly implying that dewatering or other catastrophic interruptions of life cycles did not occur here recently. Given the taxonomic and functional composition of the sampled assemblage from this site, the result of the bioassessment evaluation of moderate impairment may be somewhat harsh.

Sampling at Site DC3 produced only 264 animals in the entire collection. Whether this dearth of creatures was due to an actual scarcity of invertebrates at the site, or to inadequate sampling effort is not clear. In any event, sample size is marginal, and interpretations must be judged with care. Only 3 mayfly taxa were collected here, but the biotic index value (3.95) was only slightly higher than expected. More than ¼ of all organisms in the sample were tolerant types. The functional composition of the assemblage was skewed toward filter-feeders, which made up more than half of the animals sampled and implies an abundance of fine organic particles in suspension. These findings suggest that mild-to-moderate nutrient enrichment may have affected the biota in this reach of Dupuyer Creek.

The 9 "clinger" taxa collected here are fewer than at most other sites in the Dupuyer Creek drainage. Three caddisfly taxa are fewer than expected, as well. Still, 76% of sampled animals were "clingers", and nearly 54% were caddisflies. This seems to imply that fine sediment deposition did not obliterate clean hard substrates. Stonefly richness (3) was low, but included an abundance of the perlid *Calineuria californica* and a single salmonfly, *Pteronarcys californica*. These findings are difficult to interpret. The abundance of stoneflies has not been demonstrated to be associated with the integrity of reach-scale habitat features, while the richness of stonefly taxa has been shown to correlate with reach-scale habitat measures. The presence of 5 long-lived taxa indicates that dewatering or other catastrophes that would limit life cycles were not a recent source of impairment to biotic health at this site.

Figure 2. Comparison of total bioassessment scores (reported as percent of maximum score) for 14 sites in the Two Medicine River Watershed. August and September 2002. The revised Montana Valley and Foothill Prairies bioassessment method (Bollman 1998) was used to calculate scores for Sites DC1-DC4, BC1-BC4, TM1-TM2 and RC1; the Montana plains ecoregions reference (Bukantis 1998) was used to calculate scores for Sites DC5, BC5 and TM3.

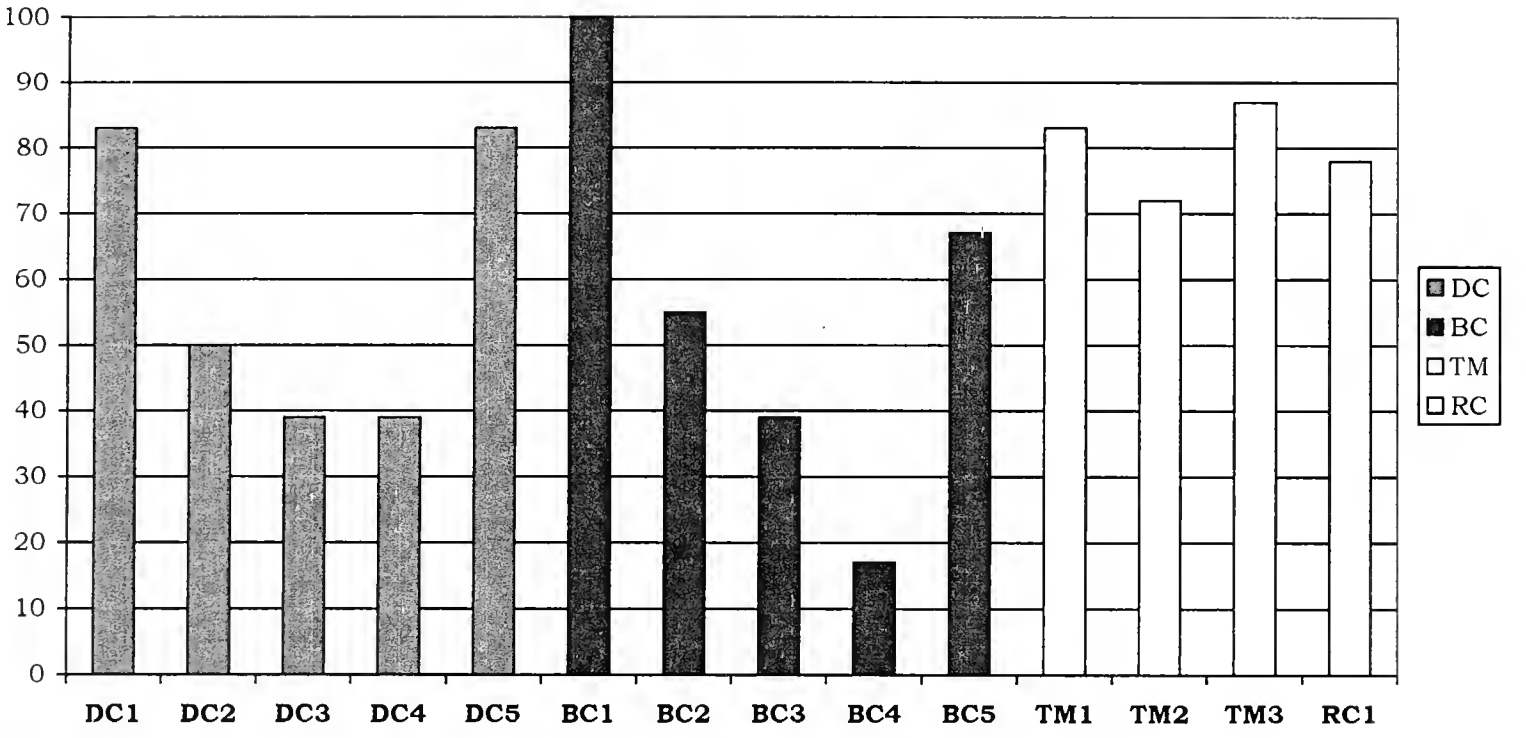


Table6. Metric values, scores, and bioassessments for 11 sites occurring in the MVFP, August and September 2002. Site locations are given in Table 1a. The revised Montana Valley and Foothill Prairies bioassessment method (Bollman 1998) was used to calculate scores. Sites marked with an asterisk yielded samples that contained too few organisms to give reliable bioassessment results.

	Dupuyer Creek				Birch Creek				South Fork Two Medicine		Railroad
	DC1	DC2	DC3	DC4	BC1	BC2*	BC3*	BC4	TM1*	TM2	RC1
METRICS	**METRIC VALUES**										
Ephemeroptera richness	8	4	3	6	11	4	3	5	7	9	6
Plecoptera richness	5	3	3	1	6	4	2	0	2	4	8
Trichoptera richness	2	8	3	3	6	4	5	2	5	5	8
Number of sensitive taxa	2	0	0	0	8	1	0	0	3	1	4
% filterers	3.16	22.27	56.06	75.15	0.31	17.24	23.49	47.35	4.49	5.41	18.21
% tolerant taxa	4.21	25.12	26.14	25.75	1.86	20.69	62.05	54.83	8.99	11.11	23.93
	METRIC SCORES										
Ephemeroptera richness	3	2	2	3	3	2	1	2	3	3	3
Plecoptera richness	3	2	2	1	3	3	2	0	2	3	3
Trichoptera richness	1	3	2	2	3	2	3	1	3	3	3
Number of sensitive taxa	2	0	0	0	3	1	0	0	2	1	3
% filterers	3	1	0	0	3	1	1	0	3	2	1
% tolerant taxa	3	1	1	1	3	1	0	0	2	1	1
TOTAL SCORE (max.=18)	15	9	7	7	18	10	7	3	15	13	14
PERCENT OF MAX.	**83**	**50**	**39**	**39**	**100**	**55**	**39**	**17**	**83**	**72**	**78**
Impairment classification*	**NON**	**MOD**	**MOD**	**MOD**	**NON**	**SLI**	**MOD**	**SEV**	**NON**	**SLI**	**SLI**
USE SUPPORT †	**FULL**	**PART**	**PART**	**PART**	**FULL**	**PART**	**PART**	**NON**	**FULL**	**PART**	**FULL**

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

† Use support designations: See Table 3a

Table7. Bioassessment metrics and scores for the three Plains ecoregions sites: Dupuyer Creek Site DC5, Birch Creek Site BC5, and Mainstem Two Medicine River Site TM3. Site locations are given in Table 1a. Montana Plains ecoregions reference (Bukantis 1998).

VALUES	Dupuyer Creek DC5	Birch Creek BC5	Mainstem Two Medicine River TM3
Taxa richness	18	18	28
EPT richness	11	11	18
Biotic Index	4.65	4.69	4.28
% dominant taxon	31.58	58.43	34.88
% collectors	59.65	75.87	60.80
% EPT	80.12	95.35	87.35
Shannon diversity	3.16	1.86	2.99
% Scrapers + shredders	40.35	23.84	26.54
# Predator taxa	0	0	8
% Multivoltine	10.38	20.64	16.90
SCORES			
Taxa richness	2	2	3
EPT richness	3	3	3
Biotic Index	3	3	3
% dominant taxon	2	1	2
% collectors	3	2	2
% EPT	3	3	3
Shannon diversity	3	1	2
% Shredders + scrapers	3	2	2
# Predator taxa	0	0	3
% Multivoltine	3	3	3
TOTAL SCORE	**25**	**20**	**26**
PERCENT MAXIMUM	**83**	**67**	**87**
IMPAIRMENT CLASSIFICATION[1]	**NON**	**SLI**	**NON**
USE SUPPORT[1]	**FULL**	**PART**	**FULL**

[1]See Table 3b for impairment classification criteria and Table 3a for use support criteria.

Site DC4 supported 6 mayfly taxa, but the biotic index value (4.67) was higher than expected for a foothills stream. This combination of findings suggests that water temperatures may have been relatively warm at this site. The taxonomic composition of the sampled assemblage offers little additional evidence to support this hypothesis, however, other than the appearance of the mayfly *Stenonema* sp. and the occurrence of the dragonfly *Ophiogomphus* sp., which prefer a warm thermal environment. There may have been some degree of nutrient enrichment as well, since the preponderance of filterers among the functional components of the assemblage suggests that fine suspended organic particles were a major energy source in this system.

Ten "clinger" taxa suggest benthic substrates free of excessive fine sediment deposition; only 3 caddisfly taxa were present, but these made up nearly ¾ of sampled animals. The site lacked stonefly taxa; *Calineuria californica* was present, but only 2 individuals showed up in the sample. The finding may be related to disruption of reach-scale habitat features. Some

limitations to long life cycles may have affected the benthic assemblage in this reach, since only 4 long-lived taxa were present in the sample, and none of these were abundant. Limitations might have included dewatering with associated thermal impacts, toxic pollution, large sediment pulses, or other events. The sample was dominated by the caddisflies *Hydropsyche* sp. and *Cheumatopsyche* sp., which together made up 69% of collected organisms. These animals contributed to the skewed functional composition of the assemblage, which was heavily weighted by filterers. Scrapers seemed to be underrepresented.

At Site DC5 downstream of the Highway 44 bridge, the benthic invertebrate assemblage in Dupuyer Creek takes on taxonomic characteristics of a Plains community. Warm-water tolerant taxa, including *Fallceon quilleri, Caenis* sp. and *Ephemera simulans* were added to the mayfly fauna, and the functional mix is simpler. The sample collected at this site produced few animals; only 171 could be found in the entire collection. This may have been attributable to degraded habitat conditions, or perhaps sampling effort was inadequate. On account of marginal sample adequacy, scores and interpretations should be viewed with caution. In spite of low taxa richness, 9 mayfly taxa were supported at the site, and the biotic index value (4.65) was within expected limits for a Plains stream.

Only 5 "clinger" taxa were represented in the sample, and only 2 caddisfly taxa were present. These groups made up large proportions of the assemblage, however, suggesting that fine sediment deposition did not totally obliterate stony substrates. The lack of stonefly taxa seems entirely appropriate for this reach of Dupuyer Creek. Predators were suspiciously lacking from the sample, which could be interpreted as a sign that instream habitats were monotonous; this could account for the low number of taxa in the sample as well. Other expected functional components were present in apparently appropriate proportions.

The Birch Creek drainage

The South Fork Birch Creek site (BC1) supported a rich, diverse, and sensitive fauna characteristic of unimpaired foothill streams. Eleven mayfly taxa were present here, and the biotic index value (3.28) was within expectations for a site with excellent water quality. Six cold-stenotherm taxa were collected, including the stonefly *Visoka cataractae* and the caddisfly *Parapsyche elsis*. Cold clean water characterized the site.

Nineteen "clinger" taxa and 6 caddisfly taxa suggest that impacts from fine sediment deposition were essentially non-existent at this site. A rich stonefly fauna (6 taxa) indicates that reach-scale habitat features were probably intact. All expected functional components were present in the assemblage.

On the mainstem of Birch Creek, Site BC2 yielded a sample with only 29 total organisms. Assessment and interpretations based on a sample with so few animals cannot be reliable. Whether the scarcity of organisms was due to degraded habitat conditions, poor water quality, torrential flow conditions, or sampling error cannot be definitively discerned from the data at hand. Sampling effort was reported to have covered 40 feet of transect and substrate was disturbed for more than two minutes. In spite of the sample size, a few observations about the taxonomic composition of the small assemblage can be made. No fewer than 16 taxa were represented, and among these were 4 stonefly taxa (including a sensitive taxon, *Cultus* sp.), and 4 mayfly taxa. It seems unlikely that habitat or water quality were disastrously impaired, given this taxonomic mix of organisms.

Another small sample was produced at the DeBoo ranch on Birch Creek (Site BC3). A very marginally adequate 161 animals were present in the sample, making scoring unreliable and interpretation of results tenuous. Thirty-five feet of transect was sampled, and substrate was disturbed for 2½ minutes. The high biotic index value (4.51) and small number of mayfly taxa (3) suggest that water quality may have been degraded by mild-to-moderate nutrient enrichment. Physid snails were present and the tolerant mayfly *Tricorythodes minutus* was abundant; these findings support the hypothesis of enrichment.

"Clinger" taxa seemed to be underrepresented; only 5 were collected. While 5 caddisfly taxa were present in the sample, four of these were represented by a single animal. These findings implicate diminished availability of hard clean substrates for colonization; perhaps fine sediment deposition compromised benthic habitats. A few long-lived taxa were present, but none were abundant; this finding is difficult to interpret given the small sample size.

The sample taken at Site BC4 yielded the lowest bioassessment score of any site in this study; it was severely impaired and did not support uses. However, characteristics of the benthic assemblage seem to contradict this result; applying the MVFP bioassessment method to the data may not be appropriate for a site that is apparently transitional between the valley and foothill ecoregion and a Plains-like environment. When the Montana DEQ Plains ecoregion metric battery is applied to the data, scores suggest only slight impairment. However, since the taxonomic composition of the sample suggests that the assemblage more closely resembles a foothill community than a Plains community, it is difficult to justify applying the Plains method to this site. Apparently, a reliable method for evaluating transitional sites such as BC4 needs to be refined.

While the biotic index value (4.84) is high, no fewer than 5 mayfly taxa were supported at the site. The apparent conflict with regard to these 2 water quality indicators suggests that water temperatures may have been relatively warm. The presence of the mayfly *Stenonema* sp. supports this hypothesis. Eight "clinger" taxa were present in the sample, which is fewer than expected, but the group was abundant, making up 77% of the animals collected. Thus, even though only 2 caddisfly taxa appeared, it seems unlikely that fine sediments obliterated clean stony substrates. There was no evidence that stoneflies inhabited the site, but this is not unexpected given the evidence for warm water temperatures. One of the 3 long-lived taxa that occurred in the sample was abundant; the beetle *Optioservus* sp. made up nearly a quarter of all sampled organisms. This suggests that catastrophes such as dewatering or toxic inputs were not recent events in this reach. All expected functional components of a warm water assemblage were present. Taxonomic and functional characteristics seem to suggest that impairment was, in fact, not severe.

Taxonomic characteristics of Birch Creek near its mouth (Site BC5) clearly resemble those of a Plains ecoregion community. Warm water taxa, such as *Stenonema* sp., *Fallceon quilleri*, and *Ephemera simulans* predominate among the mayflies. The 7 taxa collected in that order suggest that water quality was essentially unimpaired by excessive nutrients, and the biotic index value (4.69) was within expectations for a Plains reference site.

Functionally, the sampled assemblage lacked predators, which may indicate that instream habitats are rather monotonous. Other expected functional components appear to be appropriately represented. Ten "clinger" taxa were collected, implying the availability of stony substrates free of fine sediment deposition.

South Fork of the Two Medicine River drainage

Only 89 organisms were collected in the sample taken at Site TM1 on the South Fork of the Two Medicine River, making bioassessment and interpretation of results unreliable. In spite of this, even the inadequate data gleaned from the sample suggests that the site appeared to support a diverse and sensitive benthic assemblage characteristic of an unimpaired foothill stream. Three sensitive cold-stenotherms were collected, including the stoneflies *Megarcys* sp. and *Zapada columbiana*. Seven mayflies appeared in the sample, and the biotic index value (2.75) was low. These findings are typical of clean cold water unimpaired by nutrients or other pollutants.

Only 2 stonefly taxa were present in the sample, suggesting that reach-scale habitat features such as natural channel morphology, streambank integrity, or riparian zone function may have suffered some disruption. "Clinger" taxa were plentiful; fourteen of them occurred among sampled taxa, and 5 caddisfly taxa were also collected. These findings imply that hard benthic substrates were not excessively impacted by fine sediment deposition. Five long-lived

taxa were collected, suggesting year-round flow and no catastrophic life cycle interruptions. The functional composition of the sampled assemblage seemed to be entirely appropriate for an unimpaired foothill stream.

Excellent water quality apparently persisted to the downstream site on the South Fork of the Two Medicine River (Site TM2), since no fewer than 9 mayfly taxa occurred there. The biotic index value (2.04) was appropriately low for a site where water quality was intact.

Functionally, the assemblage at Site TM2 appeared to be skewed toward shredders; the dominant taxon was the caddisfly *Lepidostoma* sp. The large number of these insects present in the collection suggests an ample supply of organic debris, probably originating from the riparian zone. However, the true functional composition is probably masked by what was probably a serendipitous encounter by the sampler with a large number of early instars. Fine sediment deposition apparently did not appreciably impair the availability of hard substrates, since 18 "clinger" taxa were present at the site, and the caddisfly fauna was rich as well (5 taxa). The occurrence of 4 stonefly taxa may be associated with intact reach-scale habitat features. No fewer than 7 long-lived taxa were collected, suggesting that long life cycles developed free from interruption by catastrophic events.

Mainstem of the Two Medicine River

At its mouth the Two Medicine River (Site TM3) continued to exhibit excellent water quality and habitat conditions, judging from the benthic assemblage present there. This assemblage more closely resembled a Plains community than the foothill assemblages collected at the South Fork sites. *Leucrocuta* sp., *Isonychia* sp., and *Ephemera simulans* were among the 11 mayfly taxa in the collection, and the stonefly *Isogenoides* sp. was abundant. The rich mayfly fauna, coupled with a biotic index value (4.28) appropriate for an unpolluted Plains river suggest that nutrient enrichment was not an appreciable influence on the composition of the benthic invertebrate assemblage.

High taxa richness and the occurrence of 8 predator taxa suggest that instream habitats were diverse and plentiful at this site. Twelve "clinger" taxa and 4 caddisfly taxa were present, suggesting that fine sediment deposition did not substantially impair clean stony habitats. The integrity of reach-scale habitat features is implied by the 4 stonefly taxa taken in the collection. All expected functional components of a riverine environment were present in the sample.

Railroad Creek

Site RC1, on Railroad Creek, supported a sensitive, rich, and diverse assemblage typical of unimpaired sites on foothill streams. No fewer than 4 sensitive cold-stenotherm taxa were supported here, including the mayflies *Caudatella* sp. and *Drunella doddsi*. In all, 6 mayfly taxa were collected. The biotic index value (3.00) calculated for the entire assemblage was low. These findings suggest that cold clean water with no hint of nutrient enrichment flowed at the site.

Eighteen of the sampled taxa were "clingers" and 8 caddisfly taxa were present; fine sediment deposition apparently did not obliterate hard substrate surfaces. Six stonefly taxa were collected, suggesting that reach-scale features such as streambank integrity, channel morphology, and riparian zone function were intact. Eight long-lived taxa appeared in the sample, many of which were abundantly represented, implying that dewatering or other catastrophes did not limit biotic health at the site. All expected functional components of an undisturbed foothill stream were present.

CONCLUSIONS

The Dupuyer Creek drainage

- Excellent habitat conditions and water quality appeared to account for the rich fauna at Site DC1 on the North Fork of Dupuyer Creek.
- Site DC2 on the South Fork of Dupuyer Creek may have been slightly impaired by nutrient enrichment.
- Enrichment appeared to have an impact on the invertebrate assemblage collected at Sites DC3 and DC4 in the Dupuyer drainage. A poor showing of long-lived animals suggested the possibility that dewatering or other catastrophe also limited biotic health at these sites.
- Only tentative interpretations were possible for evaluating Site DC5, since sample size was only marginally adequate. However, water quality indicators suggested unenriched, though warm, water. Habitat conditions were probably appropriate for a Plains stream.

The Birch Creek drainage

- Excellent habitat conditions and cold clean water support a rich, diverse, and sensitive assemblage of invertebrates at Site BC1 on the South Fork of Birch Creek.
- Inadequate sample sizes prohibit interpretation of bioassessment scores, metric performance or taxonomic features for the assemblages collected at Sites BC2 and BC3.
- The transitional site at BC4 had taxonomic and functional characteristics of both foothill conditions and Plains conditions, and neither MVFP nor Plains bioassessment batteries seemed to perform appropriately. Composition of the assemblage suggests that water quality was good, though temperatures were warm. Habitat condition indicators suggested largely unimpaired instream conditions.
- The fauna at Site BC5 suggested good water quality, but monotonous instream habitats.
- Invertebrate assemblages exhibited a clear ecoregional transition between sites BC3 and BC4. Lower sites supported much greater proportions of tolerant taxa than did upper sites. Field personnel corroborate observed differences (R.Ridenour, personal communication). Increased turbidity, dissolved solids, and specific conductance were associated with the transition from a foothill assemblage to a plains-like assemblage.

The Two Medicine River drainages

- Inadequate sample size limits bioassessment and interpretation of data collected at Site TM1 on the South Fork of the Two Medicine River. However, the sample did include a diverse variety of sensitive taxa characteristic of sites with good water quality and undisturbed habitat.
- Sites TM2 and TM3 supported fauna indicating relatively undegraded habitat and good water quality.

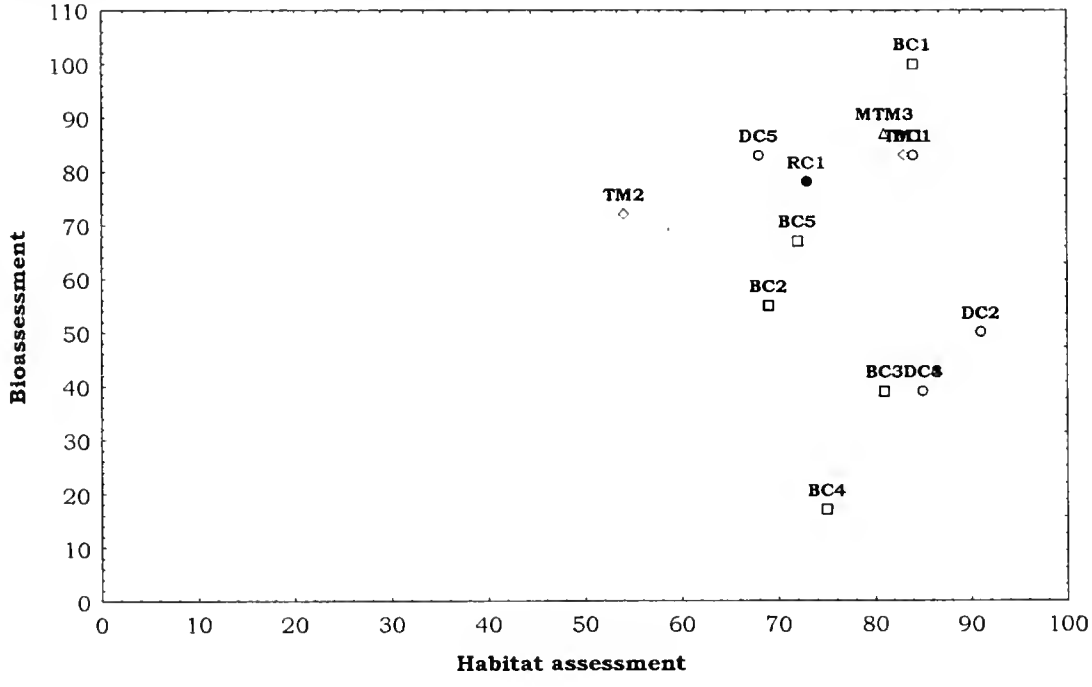
Railroad Creek

- Excellent habitat conditions and cold clean water support a rich, diverse, and sensitive assemblage of invertebrates at Site RC1 on Railroad Creek.

- Figure 3 illustrates the relationship between habitat assessment scores and bioassessment scores for the 13 sites in this study. (Recall that Site TM3 was not scored for habitat.) The symbols for three Dupuyer Creek sites (Sites DC2, DC3, and DC4) and three Birch Creek sites (Sites BC2, BC3, and BC4) fall in the area of the

graph where habitat scores are considerably higher than bioassessment scores, suggesting that water quality impairment is the major limitation to benthic assemblage composition. (Note that symbols for 2 Dupuyer Creek sites overlap; they produced identical bioassessment and habitat assessment scores.)

Figure 3. Total bioassessment scores plotted against habitat assessment scores for sites in the Two Medicine River Watershed. August and September 2002. (Barbour and Stribling 1991).



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